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(71) Applicant (for all designated States except US): ALBANY  
NORDISKAFILT AB [SE/SE]; P.O. Box 510, S-301 80  
Halmstad (SE).

(72) Inventor; and  
(75) Inventor/Applicant (for US only): ÅBERG, Bo-Christer  
[SE/SE]; Karl Ifvarssonsgatan 9, S-302 47 Halmstad (SE).

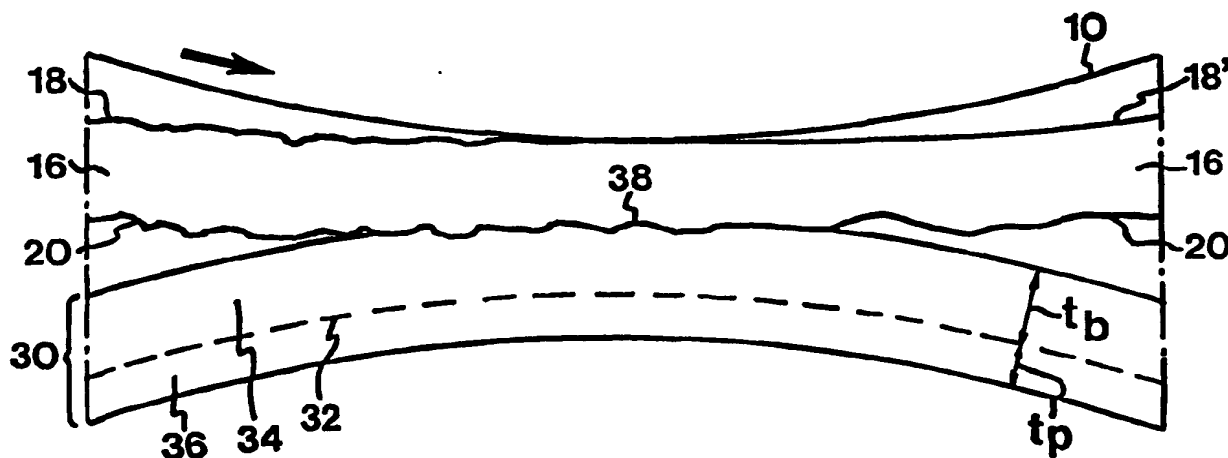
(74) Agent: AWAPATENT AB; P.O. Box 5117, S-200 71 Malmö  
(SE).

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(54) Title: CALENDERING SYSTEM



(57) Abstract

The invention relates to a calendering system in a papermaking or board manufacturing process, the system comprising at least one press nip, an endless calender belt (30) having a core (32) and a compressible, elastic material bonded to the core (32), as well as a paper or paperboard web (16) which passes together with the belt (30) through the press nip and the dewatering of which is completely or at least substantially completely terminated earlier in the manufacturing process. The calender belt (30) has in its thickness direction a first hardness on the side (34) of the core (32) closest to the web (16) and a hardness on the opposite side (36) of the core (32) that is higher than the first hardness. The first hardness is so selected in relation to the web (16) that the surface (38) of the calender belt (30) engaging the web (16) can adapt its shape in the press nip (14) to unevennesses in the surface (20) of the web (16).

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CALENDERING SYSTEM

The present invention generally relates to a system for calendering a web of paper, paperboard or the like. More specifically, the invention relates to a calendering system of the type using an endless, compressible and elastic calender belt passing, together with the web, through a press nip.

Paper or paperboard is calendered during manufacture with a view to imparting to it increased surface smoothness and gloss. In many printing papers, calendering is necessary to provide a sufficiently high printing quality. Calendering is carried out both on coated and non-coated paper or paperboard.

Calendering can be performed on-line in a papermaking or board machine immediately after the drying section thereof. In some configurations, the web is calendered at the end of the drying section. In on-line calendering, use is traditionally made of a machine calender comprising at least one press nip between two hard rolls.

Calendering can also be performed off-line, i.e. substantially separate from the papermaking or board machine, in which case use is traditionally made of a so-called supercalender, which is made up of a relatively large number of rolls placed one upon the other in a vertical stack. Normally, every other roll in the supercalender is hard and every other is of a softer material, the side of the web running on the hard roll receiving increased gloss. A more uniform treatment of the web can be achieved if the relative positions of the hard and soft rolls are changed at the centre of the supercalender.

Also in on-line calendering, calenders with elastic rolls ("soft calendering") have been developed. The soft calender, which can thus be arranged on-line after the papermaking or board machine or a coating unit, normally has a relatively small number of rolls. In soft calender-

ing, each nip is formed between a heated steel roll and an associated elastic roll, for example a polymer-coated roll. Heating, which makes the web soften in the nip, is necessary for the paper to become sufficiently smooth and glossy despite the small number of rolls. The elasticity of the roll in a soft calender entails that the press nip becomes extended, this in turn resulting in a flatter pressure pulse in the soft calender, whereby the pressure force can advantageously be limited as compared with a machine calender.

It is generally known, for example as described in EP-A1-0 361 402 with reference to Figs 1 and 2 therein, that there is an essential difference in the calendering result achieved with a machine calender using hard rolls only, on the one hand, and a soft calender using one hard, heated roll and one elastic roll, on the other. A machine calender with hard rolls calenders to a constant web thickness, however with an undesired density variation in the web as a result because of the high, localised pressure pulse giving a comparatively stronger compression of the thicker portions of the web. A soft calender, on the other hand, calenders to a more constant web density, but instead yields a web which suffers from remaining unevenness, i.e. non-constant thickness, and poorer gloss.

EP-A1-0 361 402 proposes in a soft calender to provide the elastic side of the press nip by means of a separate, relatively long calender belt which passes in an endless path around this roll and spaced from the periphery thereof outside the nip. Thus, the paper or paperboard web is located in the nip between the elastic, endless belt and the hard roll. By such a design, the calender belt, which is heated in the press nip by heat from the heated, hard roll, can be cooled during its return travel in the closed loop.

DE 36 32 692 discloses the use of an elastic calender belt which, together with the paper or paperboard web

to be calendered, passes through a press nip, e.g. in a supercalender, in an endless path around a hard roll and an additional roll parallel thereto.

To further extend the press nip in soft calenders  
5 with a view to further reducing the maximum pressure of the pressure pulse, it has also been suggested, in US 5,163,364, to use in a soft calender a press design of substantially the same type as in so-called shoe presses, which are used in the press section of papermaking or  
10 board machines. Such soft calenders have an extended press nip formed between a rotating and heated hard roll, on the one hand, and a matching, substantially stationary, concave support element, on the other, the paper or paperboard web passing through the nip along with a  
15 press casing in the form of an endless belt, which in the nip is located between the web and the support element. The calender belt passes in an endless path around the support element or the "shoe" and, as in the shoe press of a press section, is impermeable on the shoe side. No  
20 detailed description of the calender belt is given in US 5,163,364.

WO 94/05853 gives another example of a press device which is said to be usable in soft calendering and which has an extended press nip formed between a rotating roll  
25 and a shoe.

In respect of endless calender belts for use as a press casing in a glazing or calendering device, it is further known, from DE 43 22 322, to design the belt asymmetrically in such a manner that the roughness of its  
30 paper side is essentially lower than the roughness of the opposite belt side.

As disclosed e.g. in US 4,552,620, known endless calender belts for soft calendering are traditionally made up of a woven fibre base or core impregnated to the  
35 desired thickness, either on one or both sides, with a suitable impregnating substance, generally polyurethane.

A general problem of the above-mentioned known calendering techniques is that there is always an undesired compromise between smoothness and gloss, on the one hand, and constant density, on the other. Moreover, undesired thickness changes often occur in the web as a whole during the calendering process. In other words, if the thickness of the uneven surface layer of the web is designated  $\Delta$  and the remaining thickness is designated  $T$ , then one generally aims at eliminating  $\Delta$  while maintaining  $T$  constant. With today's calendering techniques, it is often necessary, depending on the contemplated use of the calendered paper or paperboard, to choose one parameter before the other. For example, one may consider the case where an image is to be printed on the paper or paperboard after calendering. Patchiness/roughness of the web as a result of poor calendering may then yield a visually poor image, but on the other hand a non-uniform density of the web may entail that the colouring/colour absorption of the image becomes irregular, this also deteriorating the image.

It is true that attempts have previously been made, as disclosed in the above-mentioned EP 0 361 402, with a view to counteracting local load peaks, to provide a more uniform load distribution on the web in the press nip by using an elastic and compressible calender belt whose elasticity is so adapted that the belt in the press nip can follow the surface roughness of the web. One problem of this known technique is however, as specifically stated in EP 0 361 402, that if the belt is made too soft, there is a risk of plastic deformation occurring in the calender belt, which drastically cuts the life thereof, whereas if the belt is made too hard, it will not be able to follow the surface roughness of the web.

A general object of the present invention is to provide a calendering system which makes it possible, as compared with the known calendering technique described above, to reduce the pressure in the press nip and at

the same time provide a product which is smoother and glossier, and has a more uniform density than what is possible with today's calendering techniques.

This and other objects of the invention are achieved  
5 by a system as defined in appended claim 1.

Thus, the invention provides a calendering system in a papermaking or board manufacturing process, the system comprising at least one press nip, an endless calender belt comprising a core and a compressible, elastic material bonded to the core, as well as a paper or paperboard  
10 web which passes together with the belt through the press nip and the dewatering of which is completely or at least substantially completely terminated earlier in the manufacturing process. The novel and distinctive feature of  
15 the invention is that the calender belt in its thickness direction has a first hardness on the side of the core closest to the web, and a hardness on the opposite side of the core that is higher than the first hardness, the first hardness being so chosen in relation to the web  
20 that the surface of the calender belt engaging the web can adapt its shape in the press nip to unevennesses in the surface of the web.

The inventive system confers, in the first place, the advantage of obviating the need to compromise  
25 between, on the one hand, a sufficiently compressible material to enable the calender belt to follow the unevennesses in the web and, on the other hand, a material which is sufficiently hard to give the web an acceptable life, especially at high web speeds.

30 The above-mentioned advantage applies irrespective of whether the press nip in the inventive system is formed between two rotating rolls or whether the press nip is an extended press nip between one rotating roll and one substantially stationary, concave support element. In  
35 both cases, it is the side of the calender belt that faces away from the web, hereinafter referred to as the press side of the calender belt, that is subjected to the

greatest mechanical action and the greatest risk of abrasion. According to the invention, the press side of the calender belt can thus be made sufficiently hard to provide an acceptable belt life, while at the same time a  
5 sufficiently low hardness can be chosen for the other side of the belt, hereinafter referred to as the web side of the calender belt.

The invention is also usable in such cases where the calender belt is used as a roll-covering in a soft calender having two rolls.  
10

Another essential advantage of the invention is that the properties of the calender belt in the press nip can be controlled much more accurately as compared with a calender belt having one and the same hardness throughout  
15 its entire thickness.

The above-mentioned first, relatively low hardness of the web side of the belt and the above-mentioned second, relatively high hardness of the press side of the belt are preferably so chosen with respect to the unevennesses of the web that the latter do not give rise to any corresponding change in shape of the press side of the belt when this passes through the press nip. In other words, said second, relatively high hardness should  
20 always be sufficient for the calender belt to produce a firm, uniform resistance in the press nip once the unevennesses of the web have been compensated for by the softer web side of the belt. It will thus be appreciated that the inventive system at the same time exhibits both the favourable features of a traditional soft calender  
25 and the favourable features of a machine calender.  
30

It should be emphasised that it is the hardness of the web side as a whole that is lower than the hardness of the press side as a whole. The invention also comprises in particular both cases where portions of the web  
35 side may have a higher hardness than the rest of that side, and cases where portions of the press side have a lower hardness than the rest of that side.



For example, the calender belt may have a surface layer engaging the web that has a hardness which is higher than the above-mentioned first hardness, in which case the hard surface layer should be sufficiently thin  
5 and flexible to enable the unevennesses of the web to "propagate" through the surface layer and be compensated for by adaptation of the shape of the underlying, softer portion of the web side.

Moreover, the calender belt may, on the web side,  
10 somewhere between the web and the relatively soft portion that is to take up the unevennesses of the web, have a barrier layer of low extensibility in MD and CD. In this way, shear movements in MD and CD of the belt, occasioned by the compression of the web side, are prevented, or at  
15 least partially prevented, from producing undesired shear forces acting on the fibres of the web in the contact surface.

The hardness of the web side of the calender belt preferably is in the range of 75-91 Shore A, and a currently especially advantageous range should be 80-91  
20 Shore A. The hardness of the web side in the thickness direction should however always be lower than the hardness of the press side in the thickness direction. The web side and the press side may be built up of different  
25 materials. Besides, it may be preferred to have a greater thickness on the web side than on the press side.

The web side of the calender belt may exhibit a continuous or a non-continuous hardness gradient in the thickness direction, which gradient may be both positive  
30 and negative depending on the application. Such a hardness gradient may be achieved, for example, by the web side consisting of several layers of different hardness.

As to the surface structure of the calender belt, the press side should exhibit sufficient frictional properties on a rotating roll, and produce a sufficient oil  
35 film if a press shoe is instead used. The surface of the web side should be relatively fine, but exert a suffi-

cient friction to prevent relative movement from occurring in MD. This can be achieved by providing a special friction-increasing material as surface layer on top of the rest of the web side of the belt.

5       The press nip of the inventive system preferably exerts an average pressure force on the web that is higher than any previous average pressure force exerted on the web in other press nips during pressing and drying, preferably higher than 4 MPa, generally in the  
10      range of 6-20 MPa.

        The temperature of the heated roll may be  $> 200^{\circ}\text{C}$ . Preferably, the heated side of the web must not be heated further down than 6-15  $\mu\text{m}$  in order that the bulk should not decrease.

15       These and other features of the invention are stated in the appended claims.

        The invention will now be described by means of two embodiments with reference to the accompanying drawings, where like reference numerals consistently designate like  
20      parts.

        Fig. 1A schematically shows a first embodiment of a calendering system according to the invention, comprising two rotating rolls.

        Fig. 1B is a broken-away, enlarged view of the press  
25      nip in the calendering system of Fig. 1A.

        Fig. 2A schematically shows a second embodiment of a calendering system according to the invention, comprising a rotating roll and a press shoe.

        Fig. 2B is a broken-away, enlarged view of an extended press nip in the calendering system of Fig. 2A.  
30

        Fig. 3 is a schematic cross-section of a calender belt that can be used in the system of Fig. 1A or Fig. 2A.

        Figs 1A and 1B, to which reference is now made,  
35      illustrate a calendering system according to the invention, comprising two rotating rolls 10, 12, defining between them a press nip 14. The roll 12 is relatively

hard, and heated. Through the press nip 14 passes a web 16 of paper or paperboard, which has been subjected to a preceding, conclusive dewatering process (pressing and drying) and which may be coated or non-coated. If coated, 5 the coated side is facing the hard roll 10. As indicated at reference numerals 18 and 20 in Fig. 1B, the web has an uneven surface before passing through the press nip 14.

The system further comprises a calender belt 30 10 which travels in an endless path (not shown) around the lower roll 12, separate therefrom. The calender belt 30 comprises a core 32, schematically illustrated by a dashed line, which may consist of a woven, single- or multi-layer design, a design of non-woven threads in one 15 or more directions, or of other designs, such as continuous layers having a perforated pattern.

As shown in Fig. 1B, the overall thickness of the belt consists of two partial thicknesses  $t_b$  (b for web side) and  $t_p$  (p for press side). The part 34 of the belt 20 30 which is facing the web 16, i.e. above the core 32 in the Figure, is referred to as the web side and has a thickness  $t_b$ , while the part 36 of the belt 30 which is facing away from the web 16, i.e. below the core 32, is referred to as the press side. As described above, it is 25 foreseen according to the invention that the hardness of the web side 34 is lower than the hardness of the press side 36 and is so chosen with respect to the unevennesses 20 of the web 16 that the surface of the web side 34 is elastically adaptable in shape to the unevennesses 20 in 30 the press nip, as indicated at reference numeral 38 in Fig. 1B.

The web side 34 may have e.g. a hardness in the range of 75-91 Shore A, and the press side 36, which at any rate should have a higher hardness, may have e.g. a 35 hardness substantially corresponding to the hardness of traditional press belts for shoe presses in the press section.

The web 16 is calendered substantially only on its top side in Figs 1A and 1B, i.e. on the side facing the hard, heated roll 10, as schematically illustrated by the smoother top side 18' on the exit side of the press nip.

5 The unevennesses 20 on the underside of the web 16 remain essentially unchanged, but can be eliminated if the web 16 is conducted through a following, similar, but reversed calendering step (not shown).

Otherwise, the embodiment in Figs 1A and 1B may  
10 exhibit one or more of the features of the invention described in the introductory part of the specification.

Figs 2A and 2B, to which reference is now made, illustrate a second embodiment of a calendering system according to the invention. In this embodiment, the nip  
15 14 is instead defined by a hard, heated roll 10 and an opposed, substantially stationary press shoe 40 supported by a stationary beam (not shown). The calender belt 30 runs in an endless path around the press shoe 40, as indicated at 42. The required frictional reduction is  
20 brought about in known manner by means of an oil film on the press shoe 40, in which case the belt 30 must be impermeable. Otherwise, essentially the same features as encountered in the embodiment of Figs 1A and 1B apply to the embodiment of Figs 2A and 2B.

25 Moreover, the embodiment of Figs 2A and 2B may exhibit one or more of the features of the invention described in the introductory part of the specification.

Fig. 3 is a schematic cross-section of a calender belt 30 that can be used in the systems described above.  
30 In this Figure, the web side 34 of the belt 30 consists of three layers 34a, 34b and 34c. The layer 34a, which is the thickest of the three and is located closest to the core 32, exhibits the aforementioned relatively low hardness to permit the shape adaptation of the web side 34 to  
35 the unevennesses 20 of the web 16. This equalising layer 34a may consist e.g. of polyurethane and have a hardness of 75-91 Shore A.

The layer 34b is an intermediate, relatively thin barrier layer of low extensibility in MD and CD, and serves to prevent movements in MD and CD of the layer 34a from producing shear forces on the fibres of the web 16, giving rise to unevennesses.

The layer 34c, also being relatively thin, is a hard, but flexible surface layer serving to prevent abrasion of the web side 34 of the belt 30. Alternatively, the surface layer 34c may be a friction-increasing layer, such as a rubber layer.

## CLAIMS

1. A calendering system in a papermaking or board  
5 manufacturing process, said system comprising at least  
one press nip (14), an endless calender belt (30) com-  
prising a core (32) and a compressible, elastic mate-  
rial bonded to the core (32), as well as a paper or  
10 paperboard web (16), which passes together with the belt  
(30) through the press nip (14) and the dewatering of  
which is completely or at least substantially complete-  
ly terminated earlier in the manufacturing process,  
c h a r a c t e r i s e d in that the calender belt (30)  
15 in its thickness direction has a first hardness on the  
side (34) of the core (32) closest to the web (16), call-  
ed web side, and a higher hardness as compared with said  
first hardness, on the opposite side (36) of the core  
(32), called press side, said first hardness being so  
20 chosen in relation to the web (16) that the surface (38)  
of the calender belt (30) engaging the web (16) can adapt  
its shape in the press nip (14) to unevennesses in the  
surface (20) of the web (16).

2. A system as claimed in claim 1, c h a r a c -  
t e r i s e d in that said first hardness is in the range  
25 of 75-91 Shore A.

3. A system as claimed in claim 2, c h a r a c -  
t e r i s e d in that said first hardness is in the range  
of 80-91 Shore A.

4. A system as claimed in any one of the preceding  
30 claims, c h a r a c t e r i s e d in that the web side  
(34) of the calender belt (30) exhibits a hardness gra-  
dient in its thickness direction.

5. A system as claimed in claim 4, c h a r a c -  
t e r i s e d in that said hardness gradient of the web  
35 side of the calender belt (30) is provided by the web  
side (34) consisting of layers of different hardness.

6. A system as claimed in claim 1, characterised in that the press nip (14) exerts an average pressure force on the web (16) that is higher than any previous average pressure force exerted on the web (16) during the preceding pressing and drying in said manufacturing process, preferably higher than 4 MPa.

7. A system as claimed in any one of the preceding claims, characterised in that said compressible, elastic material is substantially non-porous.

8. A system as claimed in any one of the preceding claims, characterised in that the calender belt (30) has a relatively thin surface layer (34c) which engages the web (16) and has a hardness that is higher than said first hardness, said hard surface layer (34c) being however sufficiently flexible in order not to counteract the aforementioned shape adaptation to unevennesses in the surface of the web (16).

9. A system as claimed in any one of the preceding claims, characterised in that the calender belt (30), on its web side (34), somewhere between the web (16) and the relatively soft part of the web side (34) whose shape is adapted to unevennesses in the web (16), comprises a barrier layer (34b) having a relatively low extensibility in MD and CD, to counteract the generation, as a result of shear movements in MD and CD of the web side (34) of the belt (30), produced by the compression of the web side (34), of undesired shear forces acting on the fibres of the web (16) in the contact surface.

10. A system as claimed in any one of the preceding claims, characterised in that the calender belt (30) has a friction-increasing surface layer (34c) engaging the web (16) to counteract relative sliding in MD between the calender belt (30) and the web (16).

11. A system as claimed in any one of the preceding claims, characterised in that the elastic and compressible material bonded to the core (32) of the calender belt (30) is impermeable.

12. A system as claimed in any one of the preceding claims, characterised in that the web side (34) of the calender belt (30) is thicker than the press side thereof ( $t_b > t_p$ ).

5 13. A system as claimed in any one of the preceding claims, characterised in that the core (32) of the calender belt (30) has, as compared with the rest of the belt (30), lower extensibility in MD and CD.

10 14. A system as claimed in any one of the preceding claims, characterised in that the core (32) has about the same extensibility in MD and CD.

15 15. A system as claimed in any one of the preceding claims, characterised in that the press nip (14) is formed between two rotating rolls (10, 12).

16. A system as claimed in claim 15, characterised in that the calender belt (30) is a roll-covering on one (10) of said two rotating rolls (10, 12), the other roll (12) being heated.

20 17. A system as claimed in claim 15, characterised in that the calender belt (30) passes through the press nip (14) as a belt (30) independent of the two rotating rolls (10, 12).

25 18. A system as claimed in any one of claims 1-15, characterised in that the press nip (14) is an extended press nip formed between a rotating, heated roll (10) and a substantially stationary press shoe (40), the calender belt (30) passing in an endless path (42) around the press shoe (40).



1/3

FIG.1A

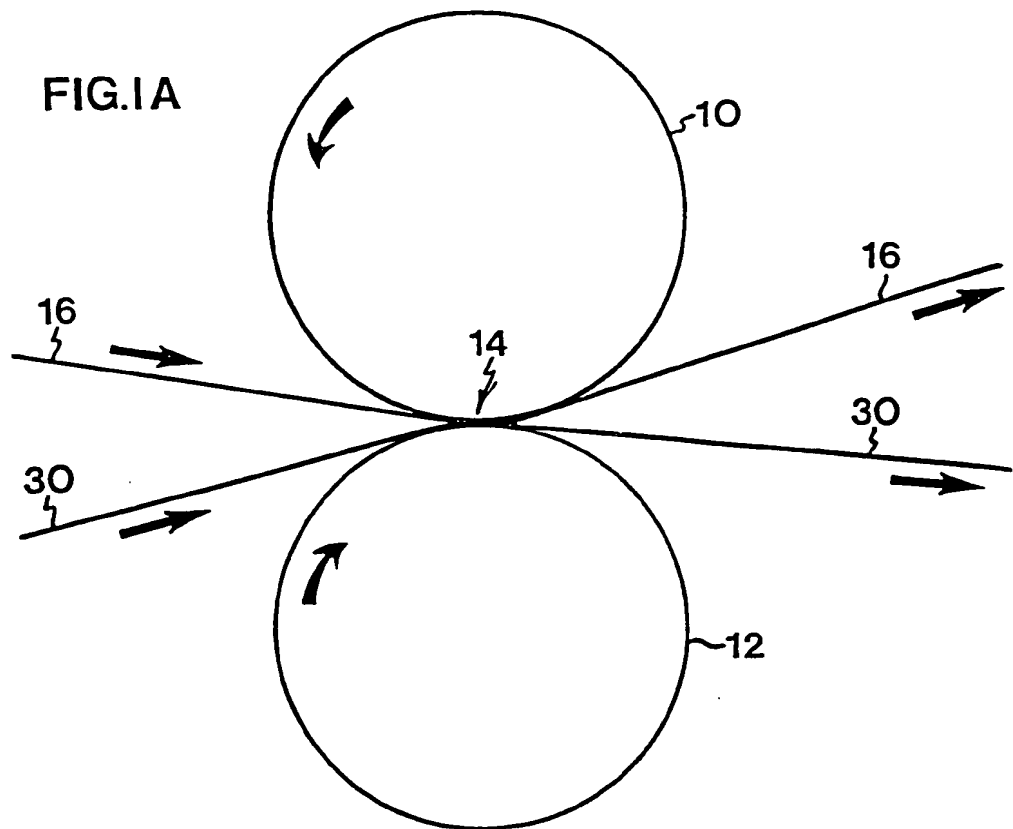


FIG.1B

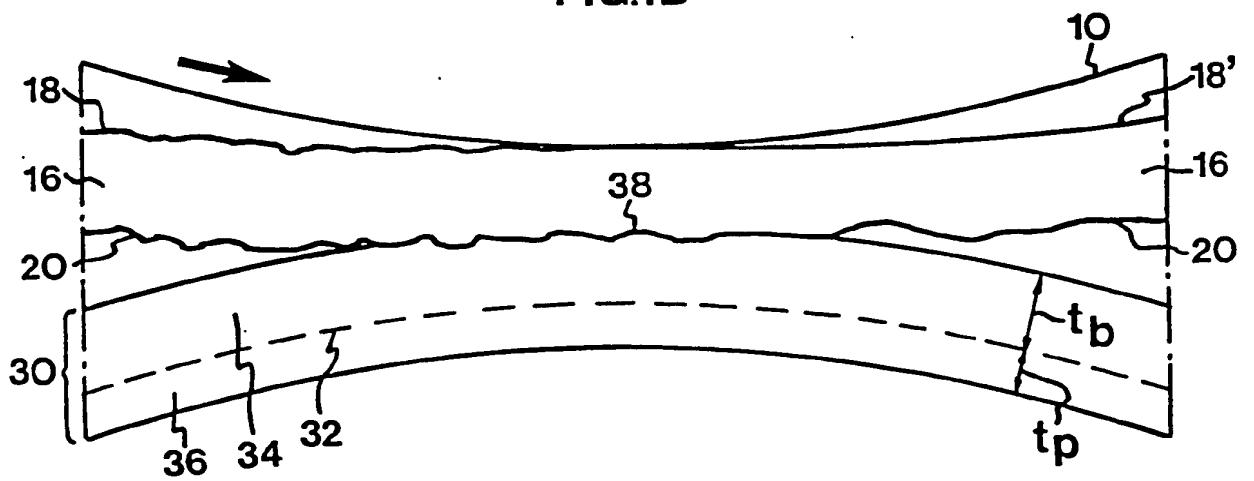


FIG.2A

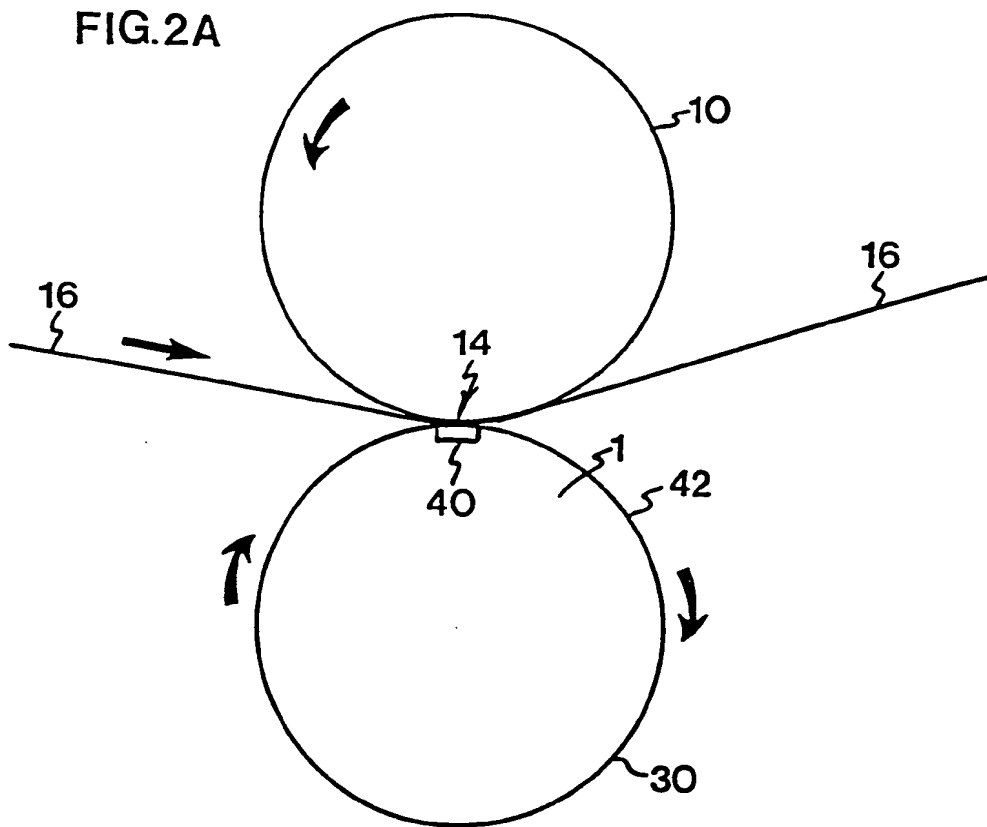


FIG.2B

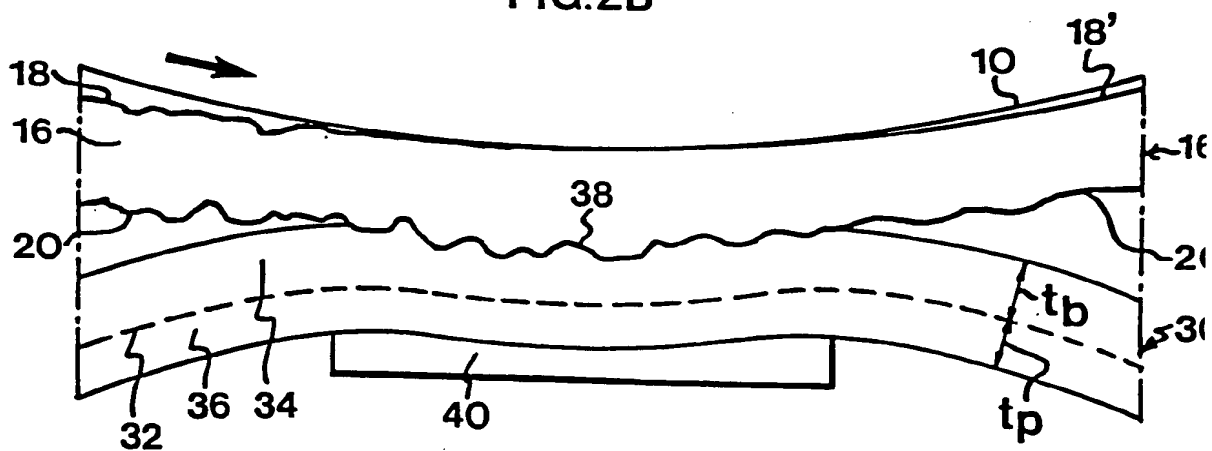
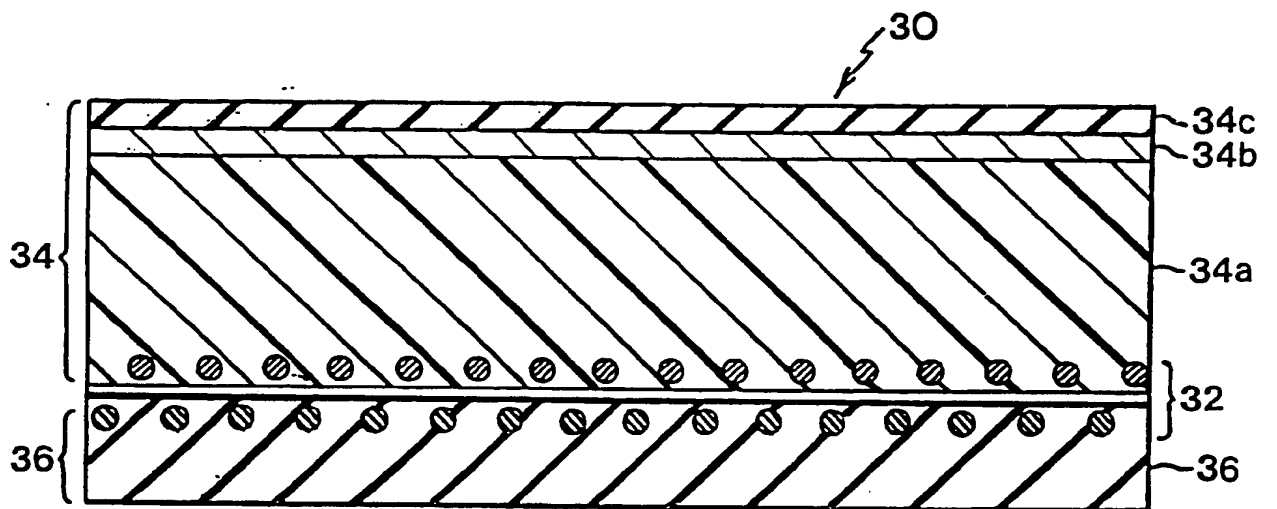


FIG. 3



## INTERNATIONAL SEARCH REPORT

International application N  
PCT/SE 95/00597

## A. CLASSIFICATION OF SUBJECT MATTER

IPC6: D21G 1/00 // F16G 1/14

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: D21G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

DIALOG: ALLSCIENCE

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim
P,X	Dialog Information Service, File 351, World Patent Index 81-95, Dialog accession no. 010002155, WPI accession no. 94-269866/33, ICHIKAWA KEORI KK ET AL: "Elastic belt for calendering paper to improve its surface - comprises base cloth and elastic resin layers on each side". JP 6200496, A, 940719, 9433 (Basic)	1
A	US 4552620 A (RICHARD J. ADAMS), 12 November 1985 (12.11.85)	1

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search

Date of mailing of the international search report

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Name and mailing address of the ISA/  
Swedish Patent Office  
Box 5055, S-102 42 STOCKHOLM  
Facsimile No. +46 8 666 02 86

Authorized officer

Olov Jensen  
Telephone No. +46 8 782 25 00

### Information on patent family members

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